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Polarization analysis of elastically scattered neutron by ^{9}Be

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Abstract : The angular distribution of the polarized and elastically scattered neutrons from ^{9}Be, has been studied using a modified form of Simon's theory The differential cross section has also been analyzed using Blatt and Beidenharn's theory The experimental data for neutrons in the energy range from 0 77 to 0.90 MeV have been fitted to the theoretical formulae. A reasonable agreement between the theoretical calculation and experimental data was found in both shape and magnitude of polarization and cross section

Keywords : Polarization analysis, elastic scattering of neutron, differential cross section

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The analysis of polarization data is of major importance in understanding the nuclear model [1, 2]. The cross section and polarization of elastically scattered neutrons from ^{9}Be in the energy range 0.77 to 0.90 MeV has been measured by Lane *et. al* [3]. This energy range includes two energy levels in the compound nucleus ^{10}Be, namely, Ex = 7.371 and 7.542 MeV respectively [4]. The quantum states of these two levels are 3^- and 2^+ respectively and the total widths are 15.7 and 6.3 keV respectively.

In previous work [5, 6], the calculation of the differential cross section and polarization have been carried out for the case of single isolated level.

One starts from the general formula of the differential cross section and polarization of neutrons in the neighbourhood of N-adjacent levels, taking into account the potential contribution. The potential may be represented in a phenomenological manner, in terms of the phase shifts and not of a hard sphere as long as the phase shifts are independent of the total angular momentum and the channel spin representation.

The reaction matrix R for the transition $\alpha s \lambda$ to $\alpha' s' \lambda'$ can be written as a sum of the potential and resonance matrices R_p and R_r respectively ; thus we have [7]

$$\langle s' \lambda' J | R | s \lambda J \rangle = R_r(\lambda) + R_p(\lambda). \tag{1}$$

Using Goldfarb and Rook resonance formula [8], one gets an expression for $R_p(\lambda)$. The expression for $R_r(\lambda)$ for N adjacent levels takes the additive form

$$R_r(\lambda) = \sum_{n=1} \mathcal{R}_r(\lambda(n)), \tag{2}$$

where

$$\mathcal{R}_r(\lambda(n)) = \langle s' \lambda'(n)\, J'(n) | R | s\, \lambda(n)\, J(n) \rangle$$
$$= e^{i(\varphi \lambda'(n) + \varphi \lambda(n))} \langle s' \lambda'(n)\, J'(n) | K | s\, \lambda(n)\, J(n) \rangle \tag{3}$$

where

$$\langle s'\lambda'(n)\, J'(n) | K | s\, \lambda(n)\, J(n) \rangle =$$
$$i \frac{g_{\alpha\lambda(n)s}\, g_{\alpha'\lambda'(n)s'}}{\left[(E-E(n))^2 + \left(\tfrac{1}{2}\Gamma(n)\right)^2\right]} e^{i\beta} \delta_{J(n)J'}(n). \tag{4}$$

A direct substitution of these reaction matrices in Blatt and Biedenharn formula [9] one gets the general formula of differential cross section [10]. Also a direct substitution of these reaction matrices in the Simon's formula for polarization [11], after introducing two corrections, namely, the Huby correction [12]

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and the non-normalization correction [13], we get the general formula of polarization [14].

For the elastic scattering of neutrons by ^{9}Be at the domain of the mentioned two energy levels in the compound nucleus of ^{10}Be, the theoretical expression of $i\langle T_1^1\rangle$ could be easily reduced to the following form :

$$i\langle T_1^1\rangle = \frac{\Delta^{\ell}}{8\sqrt{3}}\Gamma_{1_n}\Gamma_{2_n}\sqrt{c_1c_2}\sum_{\lambda_1\lambda_2\lambda_1'\lambda_2'L} i^{\lambda_1-\lambda_1'-1}$$

$$\times G_0^*(33\tfrac{1}{2}, L0, 22\tfrac{1}{2})G_1(33\tfrac{1}{2}, L1, 22\tfrac{1}{2})$$

$$\times \sin\left(2\psi_{\lambda_2}+2\varphi_{\lambda_2}-2\psi_{\lambda_1}-2\varphi_{\lambda_1}+\beta_2-\beta_1\right)D_{0,1}^{(L)}(\varphi,\vartheta,0)$$

$$+\frac{\Delta_\alpha^2}{4\sqrt{3}}\Gamma_{1n}\sqrt{c_1}\sum_{\lambda_1\lambda_2\lambda_1'J_2'\pi L} i^{\lambda_1-\lambda_1'}$$

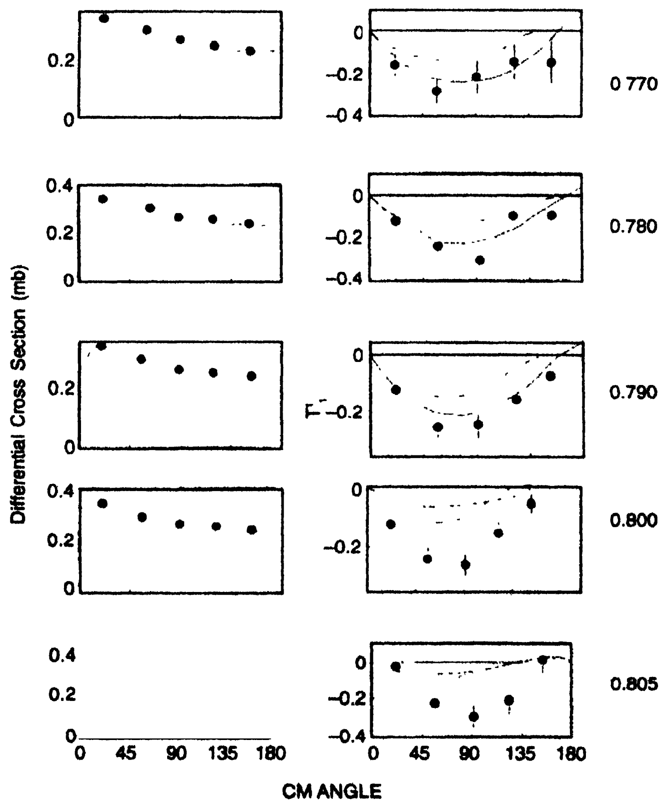
$$\times G_0^*(33\tfrac{1}{2}, L0, J_2\lambda_2\tfrac{1}{2})G_1(33\tfrac{1}{2}, L1, J_2\lambda_2\tfrac{1}{2})$$

$$\times \sin\varphi_{\lambda_2}\cos(2\psi_{\lambda_2}+\varphi_{\lambda_2}-\psi_{\lambda_1}-2\varphi_{\lambda_1}-\beta_1)D_{0,1}^{(L)}(\phi,\vartheta,0)$$

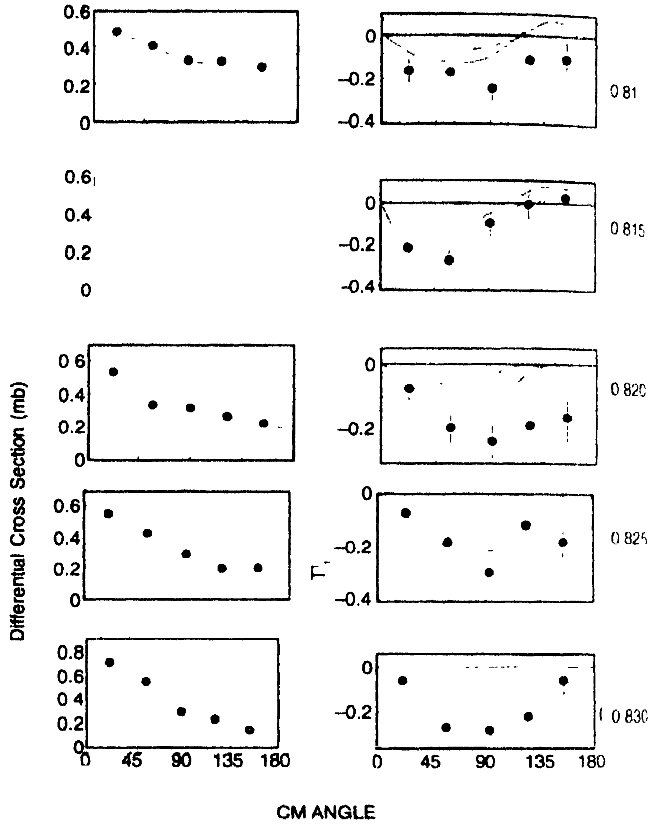
$$+\frac{\Delta_\alpha^2}{4\sqrt{3}}\Gamma_{2n}\sqrt{c_2}\sum_{\lambda_1\lambda_2\lambda_1'J_2\pi L} i^{\lambda_1-\lambda_1'}$$

$$\times G_0^*(22\tfrac{1}{2}, L0, J_2\lambda_2\tfrac{1}{2})G_1(22\tfrac{1}{2}, L1, J_2\lambda_2\tfrac{1}{2})$$

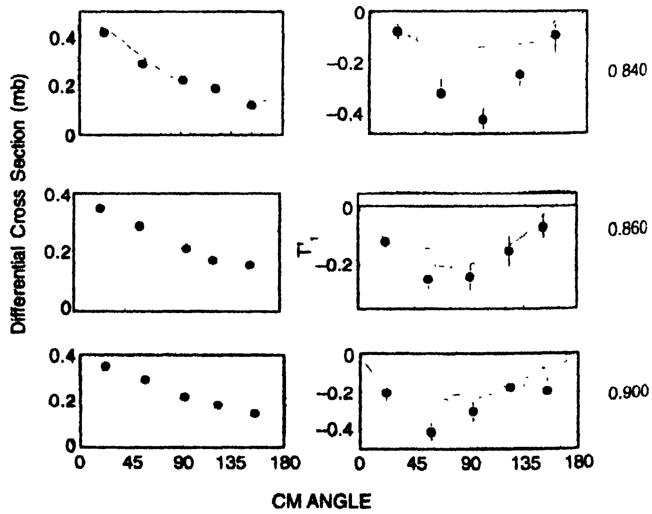
$$\times \sin\varphi_{\lambda_2}\cos(2\psi_{\lambda_2}+\varphi_{\lambda_2}-2\psi_{\lambda_1}-2\varphi_{\lambda_1}-\beta_2)D_{0,1}^{(L)}(\varphi,\vartheta,0) \tag{5}$$



(a)



(b)



(c)

Figure 1. (a-c) The angular variation of differential cross section (left and vector polarization (right) for different incident energy in MeV, as indicated in the right margin. Continuous curves represent the present calculation while the dotted curves are that due to Ref. [3].

where $c_n = \left[(E - E(n))^2 + (\tfrac{1}{2}\Gamma_n)^2\right]^{-1}$ and Γ_{1n} and Γ_{2n} are the partial widths for the neutron emission. The expression for the vector polarization will take the form

$$\vec{p} = \vec{n}\sqrt{6}\,\frac{i\langle T_1^1\rangle}{d\sigma/d\Omega}. \tag{6}$$

Eqs (5) and (6) have been used to compute the theoretical estimation of differential cross section $d\sigma/d\Omega$ and polarization $\vec{p}$. Figures (1a-c) show the theoretical calculations as compared to the experimental results as well as previous theoretical estimates. A reasonable fit has been obtained by simple two parameter (Γ_{1n} and Γ_{2n}) iteration method. The best fitted values for the partial widths for neutron emission Γ_{1n} and Γ_{2n} have been found to be 15 and 6 keV respectively for the 7.371 and 7.542 MeV levels in ^{10}Be.

References

[1] C V Sukumar and D M Brink *Nucl Phys.* **A560** 863 (1993)

[2] W S Wilburn, C R Gould, G M Hale, P R Huffman, C D Keith, N R Roberson and W Tornow *http://xxx.lanl.gov/abs/nucl-ex/9710003* (preprint submitted for publication in *Phys Rev C*) (1997)

[3] R O Lane, A J Elwyn and J R Langsdorf *Phys Rev.* **B133** 409 (1964)

[4] F Ajzenberg-Selove *Nucl Phys* **A320** 142 (1979)

[5] A A Azzam and M A Fawzy *Bull Faculty of Science* (Alexandria University) **26** 30 (1985)

[6] M M Fawzy, A A Azzam and A M Abdel-Moneim *Indian J Phys* **57** 378 (1983)

[7] A A Azzam, F A El-Akkad, A M Abdel-Moneim and E A El-Mallah *Bull Fac. Sci Alex Univ.*, **27** 221 (1987)

[8] L J B Goldfarb and J R Rook *Nucl Phys* **12** 494 (1959)

[9] J M Blatt and L C Beidenharn *Rev Mod Phys* **55A** 258 (1952)

[10] A A Azzam and M A Fawzy *Indian J Phys* **55A** 371 (1981)

[11] A Simon *Phys Rev* **92** 1050 (1953)

[12] R Huby *Proc Phys Soc* **67A** 1103 (1954)

[13] A Simon and L Welton *Phys. Rev* **90** 1036 (1953)

[14] A A Azzam, F A El-Akkad and A M Abdel-Moneim *Bull Faculty of Science (Alex. Univ.)* **27** 154 (1987)